WEATHER PROBLEMS PECULIAR TO THE NEW YORK-CHICAGO AIRWAY

551.5 : 656.7

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The mechanical difficulties in connection with the regular scheduled operation of airplanes in air transport service may now be said to be practically eliminated. This leaves the weather as almost exclusively the cause for our failure to operate on schedule whenever we do fail. The weather interrupts our schedules in several ways, which may be enumerated as follows:

1. By cutting down the visibility so that our planes may not land and take off safely at airports. The landing speeds of nearly all commercial airplanes are in the neighborhood of 60 miles per hour, so that visibility is a very necessary thing whenever it is necessary to make contact with the ground.

2. By coating our planes with ice, as mentioned in another paper, which is apt to set up terrific vibration on the struts and wires of the plane and may even cause structural failure in itself which would end the flight, or by overloading the plane with ice and at the same time decreasing its forward speed by increasing its head resistance, so that the plane will actually fall out of the air if the pilot has not been wise enough to land before this moment arrives.

3. By giving us head winds that subtract from the speed of the plane to such an extent that it no longer has an advantage over other means of transportation in the matter of speed.

4. By carrying us off of our courses with cross winds flying through the clouds where nothing is visible.

All of us who have any faith in the future believe that we shall conquer all of these obstacles so that eventually airplanes may be flown on regular schedules. In the meantime, in order to adhere to schedules as closely as it is possible, there are certain things that must be done. The following weather service must be provided and is being provided by the combined efforts of the United States Weather Bureau and the Airways Division of the Department of Commerce:

1. Weather reports are furnished every hour from selected points along the airway. These points in the flat country are usually airway intermediate fields about 60 miles apart. In the mountainous country these weather reports must come from the highest points as well as from some of the low points, since the airplane must fly at sufficient height to clear the highest mountains. These reports are:

(A) General weather conditions.

(B) Ceiling or height of the base of the clouds, if there are any at that particular point, measured in hundreds of feet.

(C) Visibility along the ground expressed in miles.

(D) Wind direction and velocity on the ground.

(E) Ground temperature.

(F) A barometer reading corrected to sea level.

(G) Any unusual field conditions, if the report comes from an intermediate field, such as depth of any snow that might be on the ground, soft condition of the field, if there is such, and any failure of the lighting equipment that may have occurred.

2. A short summary of the weather conditions as they are along the route and a forecast of the probable weather conditions for the next three hours is provided by a trained meteorologist of the Weather Bureau. He should be and is familiar enough with the problems of flying so that he can advise whether flights should be attempted during that period, the probabilities as to ice conditions, the height of the clouds on their topside, the probable changes in wind direction and velocity that will be encountered aloft, and changes in temperature that may be expected. In order to do all of this, a weather map for that particular area is drawn every three hours from information furnished by regular Weather Bureau stations within the area. This information should include dew points for the forecasting of possible fog and possible ice conditions.

3. After the plane is in flight the weather reports along the airway are furnished to the pilot every hour by radio so that he may be kept advised of any changing conditions. Our altimeters all measure altitude by measuring changes in air pressure, so that if the pilot is flying through or above the clouds he needs to have the barometer readings furnished to him regularly so that he may correct his altimeter for any fall or rise of the barometer that may have occurred while the plane is in flight. If fog or other weather conditions reduce the visibility at his destination so that it is not safe to attempt a landing there, weather reports are obtained from alternate airports in that vicinity and furnished to the pilot, so that he may either land at one of these alternate airports, if this is possible, or return to some point where a safe landing is possible.

The New York to Chicago airway commencing at New York starts with an elevation of almost sea level and progresses over large valleys, divided by fairly steep hills and mountain ridges to Bellefonte, Pa. These hills gradually increase in height from 500 feet in the vicinity of New York until it is necessary to fly at 3,000 feet above sea level in order to clear the mountains safely just before reaching Bellefonte. At Bellefonte the terrain rises very rapidly to a high plateau whose surface is very rough and rolling and is marked by relatively low broad mountain ridges and deep narrow river valleys. This plateau tapers off gradually to the flat Ohio Valley west of the Alleghany River. The elevations are such that it is necessary to climb rapidly to the 3,000-foot level on leaving Bellefonte in order to clear the highest points in safety and to maintain this altitude for 60 miles. The plane may then be brought safely down to the 2,500-foot level until the Alleghany River is reached, at which point an elevation of 2,000 feet becomes safe. It is necessary to maintain this elevation until within sight of Cleveland. The elevation of the intermediate field at Bellefonte is 1,000 feet and that of the Cleveland airport is 800 feet. From Cleveland to Chicago the country is fairly flat and level, with a stretch of 60 miles of rolling high country between Bryan, Ohio, and Goshen, Ind. The airway borders on the southern tip of Lake Erie from Cleveland to Toledo and crosses the southern tip of Lake Michigan just before reaching Chicago.

As a general rule the New York to Chicago airway is affected by all of the storms experienced in the United States as they move toward the St. Lawrence Valley, whence they all leave this continent. The paths of these storms may be roughly classified as follows:

(A) The most frequent ones are those that sweep along the Canadian border to the north of us from west to east.

(B) The storms which move southeastward from the Canadian northwest and then turn northeastward somewhere in the Mississippi Valley.

(C) Storms that originate on the Mexican border or beyond and move northeastward across our path.

(D) Storms that originate on the South Atlantic coast or in the West Indies and follow the Atlantic coast northeastward to Newfoundland.

In addition to the cyclonic storms mentioned, ground fogs are one of the chief causes of our irregularity of operations. The pure ground fog, which has a clear sky above it, is usually a local condition and usually causes only a few hours' delay or the use of an airport not located in the fog area.

The weather conditions that affect flying vary with the seasons of the year, so that we will discuss these by seasons, taking the summer season first. During the summer season ground fogs are very prevalent along the Atlantic seacoast and in the river valleys through the mountains. From Cleveland westward to Chicago ground fogs are encountered a great deal less frequently. Whenever the dew point hovers within 5° of the temperature at any terminal station the pilot is on the alert inasmuch as he gets this information by radio every hour. Ground fogs are more prevalent during the early morning hours and usually disappear as the sun climbs above the horizon. By providing our planes with fuel sufficient for at least five hours of flying and by the use of the radiobeacon and the weather broadcasting, it is many times possible for our planes to hover over their destination, flying in large circles awaiting the dissipation of the ground fog, when this has been forecast, and landing as soon as the fog lifts sufficiently to permit this. Before the advent of radio and this specialized weather service it was necessary for our planes to wait at the last clear point until the fog had lifted before starting for the terminal. Since ground fogs are very prevalent around New York City, it may safely be said that many hours of delay have been eliminated by this service in delivering the night mail to that city. Safe landings on large airports, such as the Cleveland airport, may be made at night through fog that is not more than 500 feet thick by the aid of the boundary light and red fuses strung across the field. Such landings are possible at night when they are not possible in the daytime because the lights will show vertically upward through the fog. In order to make such a landing, the pilot needs to have the very latest barometer reading so that he may correct his altimeter accordingly, and this can only be furnished by radio. The location of the field itself is determined by the radiobeacon located at one corner of the field.

Local thunderstorms of moderate intensity are encountered during the summer months between New York and Cleveland. These storms, with slightly increased intensity, are also encountered between Cleveland and Chicago, but the tornado of the southwest and midwest is very rare indeed. The thunderstorms that we encounter present a hazard which is mostly mental. There is probably no authentic case on record where an airplane has been struck by lightning while in flight, and our more experienced pilots do not even take the trouble to fly around these that are of small area. Here, again, the hourly weather reports keep the pilot advised as to their frequency and area. The two greatest hazards in connection with a thunderstorm are its vertical turbulance, which may dash to the ground any airplane that attempts to fly through one too close to the ground, and the brilliancy of the lightning at night, which may blind the pilot so that he will temporarily lose control of the airplane because he can not read his flight instruments. To correct these two possibilities, the experienced pilot will probably fly at least 1,000 feet above the highest points on the ground in going through a thunderstorm, and our planes are equipped with very brilliant instrument lights for such occasions. These bright lights are dimmed by a rheostat for ordinary flying conditions at night. In flying through a thunderstorm the pilot must, of course, switch off his radio set so that he will not be deafened by the sharp static crashes caused by the lightning.

In the ordinary summer storm the bottom layers of the clouds are usually within 200 or 300 feet of the ground in the flat country, and they envelop all of the higher ground, the hills, and the mountain tops, so that a flight between New York and Cleveland under such conditions must be made nonstop, since it will be dangerous to attempt to land at any intermediate point if the storm covers all of this area. If the flight be a westbound flight it will be made at an elevation of about 3,000 feet to clear all of the mountain tops safely, to avoid the loss of airplane speed that would result from flying at any higher altitude, and to have as little of our prevailing west winds as it is possible to have. If the flight be an eastbound flight it would usually be made by climing through the clouds to their topside, since it is easier to fly above the clouds than it is to fly through them, and because favorable winds may be expected aloft to more than compensate for the loss in airplane speed caused by the altitude. These altitudes for the topside of the clouds will vary between 5,000 and 15,000 feet, depending upon the general conditions. For all such flights the pilot needs to have weather reports broadcast hourly so that he may be kept advised of any changing conditions on the ground. He needs to have barometer readings so that he may keep his altimeter correctly set, and he needs to have weather reports from alternate airports near his destination should the weather become unsafe for landing at his destination. Before the flight is started he needs to be assured by the meteorologist that weather conditions will not change for the worst at his destination and to be furnished with the probable direction and velocity of the winds at various altitudes. Until quite recently this latter information concerning the winds aloft was an unknown quantity, since the meteorologist had no means of measuring these in a storm. But the pilots' reports and the speeds actually made by our airplanes under such conditions, coupled with the weather maps, have given us all an insight into what we may expect. The radiobeacon provides a sure path for the plane through the clouds under such conditions and the radio marker beacons keep the pilot advised as to his progress along the airway.

The advent of winter brings us the ice problem, which is probably our greatest one. When freezing temperatures prevail the process of flying through the clouds is an impossibility, and since the storms with their attending low clouds are more frequent in the winter time than at any other time our flying is greatly curtailed during the winter months. Such information as dew points, ground temperatures, and ground elevations become very necessary for any flying that may be attempted during this period, as explained in another paper. Snow itself is not the hazard to flying that it is generally considered to be. The dry snowflakes of the real low-temperature snowstorm do nothing more serious than to cut the visibility down to a very low point. The clouds in such a snowstorm are usually higher above the ground than are those in a rainstorm, so that it is possible to fly through this sort of a snowstorm and see straight down even though there is no visibility ahead. Under such conditions it is almost impossible to measure in any way from the ground the ceiling or height of the clouds, since a balloon or the ray of the ceiling light is quickly swallowed up by the snowflakes themselves. In the mountainous country the clouds usually envelop only the highest points, so that it may be possible to fly below the clouds until these points are reached and then through them over the high points themselves. Under such conditions the ice that accumulates on the plane while flying through the clouds for 5 or 10 minutes is usually not enough to cause any serious trouble with the plane from vibration or extra weight.

However, the snow that we get in the wake of each storm caused by cold northwest winds blowing across Lakes Michigan and Erie, which are relatively warmer, and then over colder land again are a very different thing. This sort of snow is apt to be a very wet snow, and as a result very apt to cling to the airplane in the form of ice. A wet moist fog generally accompanies such snow and causes a further precipitation of ice upon the plane. This sort of snow is prevalent on the south and east shores of Lakes Michigan and Erie and is apt to carry eastward from Lake Erie to the Appalachian Mountains. It disappears almost entirely east of Bellefonte.

A flight under similar conditions between Cleveland and Chicago may sometimes be made by flying beneath the clouds all of the way, but it is usually necessary to fly through the clouds over the high point on the Ohio-Indiana State line.

The clouds in a storm usually have a tendency to remain above flat territory but to arch down to meet and envelop any high points along the way. A plane flying from New York to Cleveland at an elevation of 3,000 feet may, and frequently does, find itself beneath the clouds over the valleys but very much in the clouds when flying over the ridges and high points even though the elevation of the plane has not been changed. Under such conditions the clouds themselves are seldom cut off sharply on their lower side, and there are occasional breaks in their lower layers so that it is many times possible to fly through these lower layers at a safe elevation and to catch an occasional sight of the ground for location.

The clouds themselves frequently exist in solid layers so that the pilot may find himself flying between layers for extended periods. If this be over mountainous country these layers usually meet over the high points and separate again when the next valley is reached. It is the ultimate plan to place radio marker beacons on the strategic high points so that the pilot flying under such conditions may know when he has passed any one of these. For any flying done under such conditions the pilot must, of course, have a very definite knowledge of the ground elevations below him so that he may always fly at a safe elevation. When the destination is reached and the ceiling is reported as very low the usual procedure is to come down to an elevation of about 500 feet above the actual reported ceiling and to fly along at this elevation until a hole appears in the clouds where a quick descent is made until plane is beneath the bottom layers.

Pilots need to be kept advised by the meteorologist of the location of the line-squall or wind-shift, line if there is such, since this line is usually an area of great turbulance and possible thunderheads. Having been advised of the location and probable movement of the line squall before the flight is started, the pilot can then check its progress with reference to his flight by the hourly weather reports.

With the approach of autumn come shorter days, larger and more frequent storms, lower temperatures, and more fog in connection with the storms. The pilot needs to be a little more careful in pushing through the storms because of the greater possibility of the fog beneath them, particularly when on-shore winds of low velocity prevail at New York, Cleveland, or Chicago. The ice condition begins to appear at the higher altitudes, so that flying through storms begins to be a process of flying through the clouds rather than over them on eastbound trips. It is not possible to safely come down out of the clouds where low ceilings prevail at night, unless this is done over a lighted area, and if this lighted area be a city there are many tall buildings that makes this process very dangerous, so that the shorter days curtail a great deal the bad-weather flying that can otherwise be safely done.

With the approach of a storn from the Mexican border during the winter months the temperature usually rises above the freezing point. Unless the southwest winds be very strong under such conditions, fog is apt to envelop the whole area, particularly so if there be a great deal of moisture on the ground in the shape of snow. As the storm passes to the north the temperature will drop at the wind-shift line, and while flight may be possible in the southwest corner of this storm the freezing zone will be encountered again as the wind-shift line passes, and our pilots have to be very careful of the ice danger in flying through this wind-shift zone and into the snow flurries that usually come from the lakes in the wake of the storm.

Sleet and freezing rain are other winter possibilities which are encountered occasionally. In a freezing rainstorm the ice usually forms upon the plane and weights it down to the ground within five minutes, so that no attempt is usually made to fly under such conditions. In a sleet storm the ice does not form on the plane so fast and it may be possible to climb quickly to the warmer temperatures above that usually exist in these cases and thereby get out of the ice danger. Under such conditions of inversion it is sometimes possible to get above the clouds on eastbound trips, and even though the temperature be below the freezing point at that altitude any accumulation of ice will usually disappear by evaporation. It is sometimes found under such conditions that the inversion only extends to a certain altitude and that the normal temperature lapse rate with altitude then occurs. Under such conditions the pilot must stay in that zone where the temperature is above the freezing point, and this will usually be somewhere in the midst of the clouds.

We are equipping our planes as fast as it is possible with hygrometers and air thermometers so that the pilot may avoid the ice condition, when it is possible, by choosing an elevation which will give him a temperature and a humidity where the ice hazard is not present. The air thermometer serves as an ice-wanring indicator also because when ice forms on its exposed heat-measuring element the temperature recorded in the cockpit will be that of the freezing point. Any departure from this temperature either up or down will immediately indicate to the pilot that ice has ceased to form upon the plane.

The advent of spring brings us warmer temperatures over moisture-soaked ground, so that general fog conditions are apt to prevail during the spring months. The temperature will usually cross the freezing zone each time a storm approaches and recedes, so that actual ground visibilities are apt to be less at these times than at any other. The ice hazard is greatest at temperatures near the freezing point and is therefore at its worst in the springtime. The fact that the emergency fields are very apt to be too soft for safe landings due to the thawing conditions makes attempts to fly when weather conditions are doubtful during the spring months very hazardous to airplanes.

Because ice seems to be the greatest hazard to aviation, the Daniel Guggenheim Foundation for the Promotion of Aviation has endowed a research laboratory in the physics department of Cornell University. A test wind tunnel in a chamber has been installed and the ice conditions have been duplicated in the laboratory. Close cooperation and exchange of information between the Airways Weather Bureau stations of the New York-Chicago Airway, the experimental laboratory and the National Air Transport (Inc.) have made this possible. Attempts of various kinds to solve the ice problem and remove the hazard are being made in the laboratory, and those that appear to have possibilities will be given further tests upon our planes this winter. All of us who are cooperating in the effort believe that the solution of the problem will be found at sometime in the near future.

EXPOSURE OF RAIN GAGES

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One of the main problems confronting a Weather Bureau man in establishing a new station is proper exposure for the rain gage.

It should be remembered that the standard rain gages located at the various 4,000 Weather Bureau stations in the United States furnish the only available precipitation records procurable for consultation, and for that reason they should be as nearly comparable as possible.

Prominent meteorologists, who have given this subject much thought and experiment, admit that when there is no wind large and small drops of rain, fine particles of mist, and even light snowflakes will settle down vertically to the ground, and the records of all gages within a mile or two will correspond quite closely when considered over a long period of time if there are no topographic effects to be considered. If there is a wind blowing the larger drops, falling swiftly, go into the gage without much effort, while the lighter ones are apt to be carried off to one side. Snowflakes have been known to enter a gage and then be whirled out again, making the catch decidedly deficient. This deficiency has been variously estimated from almost nothing to over 10 per cent.

Being interested in the subject and wishing to know first-hand what this difference in catch would be in Kansas, I procured a standard 8-inch gage over five years ago and set it up on a grass plot at my residence on Shawnee Avenue, Topeka, Kans., a distance of about 17 city blocks from the Weather Bureau office. The gage is well protected by trees and buildings, so that there is not apt to be any interference due to direct winds immediately at the gage. All the objects are at least as far away from the gage as their height above it. The ground between the Shawnee Avenue gage and the Weather Bureau is but slightly rolling, so there are no topographic effects worth mentioning. Whereas the Shawnee Avenue gage is located on the ground, the Weather Bureau gage is located on a flat roof of a 6-story building which is considerably higher than surrounding buildings. This roof is somewhat protected by a 5-foot parapet at the edge of the building, but the wind has a much better sweep over that gage than the one located on the ground.

Daily observations of the catch of the two gages for the 5-year period ending September 30, 1929, are offered herewith for comparison's sake. The graphs for the individual months invariably show greater catches for the ground gage. This was especially noted when the wind was gusty or squally, while at periods when the wind movement was very light or nearly calm the two gages would average about the same. In fact, the daily record shows many instances when they correspond exactly. It will be observed by the graphs that the greater differences always occurred during the summer months, when the precipitation mostly occurs during thundershowers, at which time the winds are apt to be quite high and of a shifting nature. In winter, when the precipitation is in the form of snow, as a rule, the monthly totals agree closely, and there is even then a slight advantage in favor of the ground-exposed gage. From a negligible difference in January the differences increase gradually until about the 1st of April, when the thundershower period commences, after which the increase is decided and continues so until the closing days of September, and then recedes to conditions similar to those found at the first of the year. In other words, the greatest difference in catch is during the growing season of the year. That being the case, it was decided to also compare these particular differences for the two seasons of the year, the winter and growing season.

The first charts exhibited indicate the monthly catches and we find the following:

Taking the full year's record into account and commencing with the first entry, October, 1924, the first year the catch in the ground gage was 28.47 inches and the roof gage 25.93 inches; the second year the ground gage totaled 32.47 inches and the roof gage 29.46 inches; the third year, 49.78 inches to 46.54 inches; the fourth year, 30.15 inches to 27.96 inches; and the fifth year, 38.63 inches to 34.71 inches. In other words, the annual catch in the ground-exposed gage exceeded the roof gage the first year 2.54 inches; the second year, 3.01 inches; the third year, 3.24 inches; the fourth year, 2.19 inches; and the fifth year, 3.92 inches. The average annual difference in catch for the five years was 2.98 inches. Expressed in percentages, the ground-exposed gage exceeded the roof gage the first year by 10 per cent; the second year, 10 per cent; the third year, 7 per cent; the fourth year, 8 per cent; and the fifth year, 11 per cent. The average for the 5-year period is 9 per cent.

In consulting all the charts—monthly, annual, and average—for five years for the two seasons mentioned in the fore part of this paper, the winter season, and the growing season, we have the following: During the winter season, October to March, inclusive, the ground-exposed gage collected the first season 6.04 inches, while the roof gage collected 5.68 inches; the second season the totals were 10.66 to 9.16 inches; the third season, 14.43 to 14.09 inches; the fourth season, 6.92 to 7.53 inches; and the fifth season, 15.85 to 14.48 inches. The differences this time, by seasons, amounted to 0.36 inch, 1.50 inches, 0.34 inch, −0.61 inch, and 1.37 inches. This, given in percentages, was 6, 16, 2, −8, and 9, or an average for the entire period of 6 per cent.

Taking the growing season, April to September, for study, the ground-exposed gage showed a total of 22.43 inches the first season, as compared to 20.25 inches on the roof; the second season, 21.81 to 20.30 inches; the third season, 35.35 to 32.45 inches; the fourth season, 23.23 to 20.43 inches; and the fifth season, 22.78 to 20.23 inches. The differences here are for the first season, 2.18 inches; the second, 1.51 inches; the third, 2.90 inches; the fourth,